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US LARP

Status and plans of mechanical analysis of different 2nd generation IR quad designs

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OUTLINE:

- Goal and plans
- Where we are now
- Next steps

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Goal and plans

GOALS: - Study and compare mechanical designs for both shell and racetrack type quadrupoles in order to select the best design concept for the 1st short model,

- Have engineering design by the end of FY05.

Candidates:

- Shell type ϕ = 110 mm with Aluminum outer shell
- Shell type ϕ = 110 mm with Stainless Steel skin
- Racetrack type ϕ = 92 mm with Al/SS skin

Criteria:

- Acceptable stress and strain in the coil
- Acceptable coil deformation

STEPS:

- Analytical analysis
- FEM with fixed BC
- FEM with external forces
- Full FEM model (conceptual)

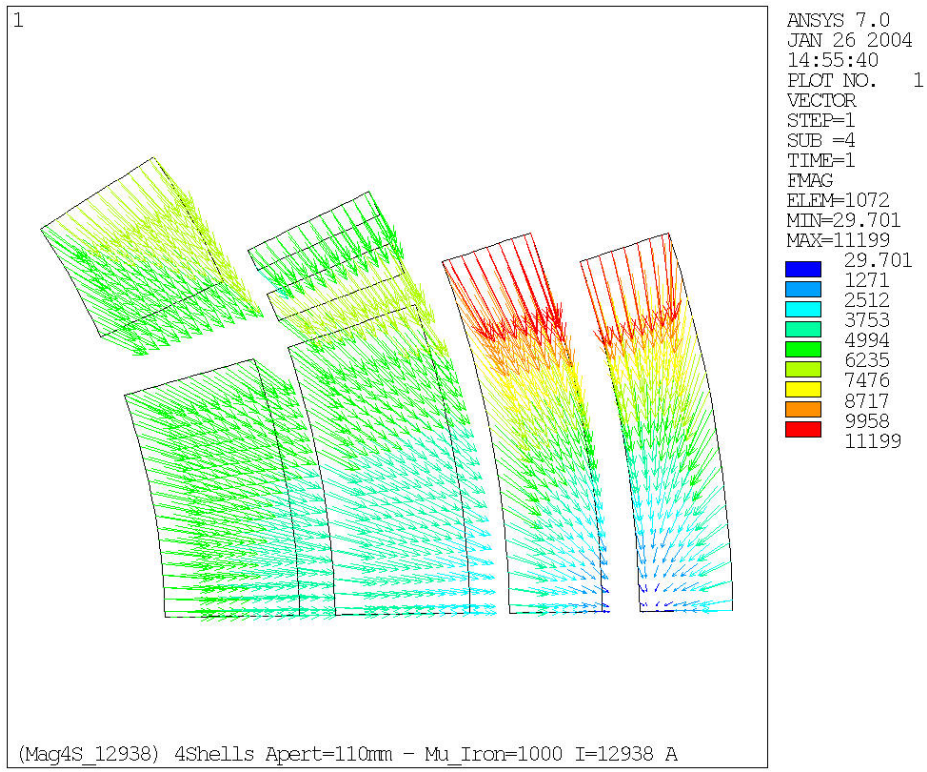
Shell type – Magnetic forces

- **Forces computed by ROXIE and ANSYS**

  @ I=13kA (= 228 T/m)

	ROXIE (MN/m)	ANSYS (MN/m)	HGQ† (MN/m)
F_X	4.2	4.2	1.6
F_Y	-4.2	-4.1	-1.9
F_R		2.8	
F_θ		-5	

† KEK design scaled to 228 T/m



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Shell type – Analytical study

- **1st shell: F_θ = 1.5 MN/m,**
  - **Width = 12.3 mm,**
    - ➔ **σ_θ = 122 MPa**

- **Bottom half of coil: F_r = 1.7 MN/m,**
  - **E_{r_coil} = 50 GPa, E_{r_ins} = 14 GPa**
    - ➔ **Δr = 87 μm (average)**

    And this deflection is going to increase the stress in the 1st shell!

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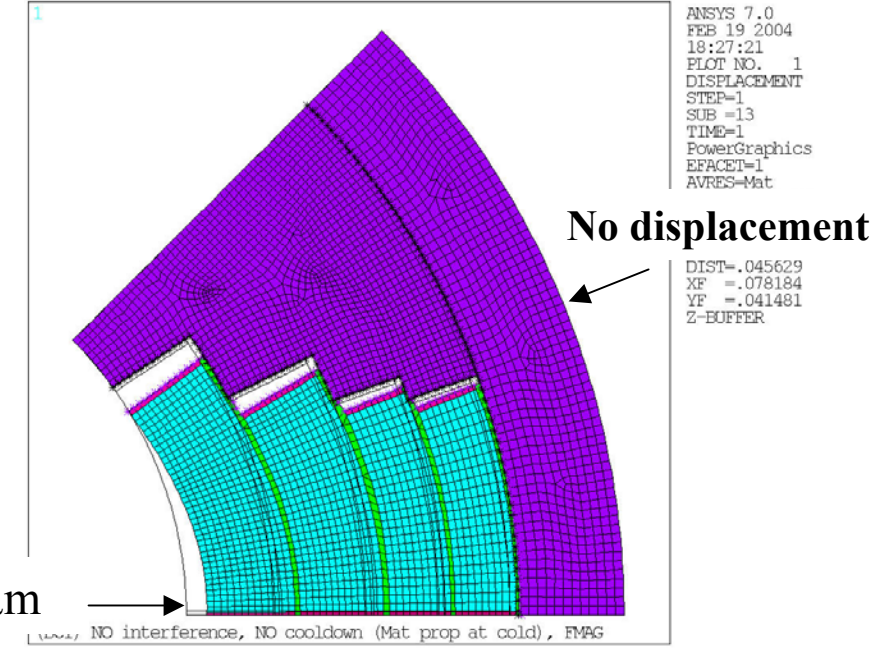
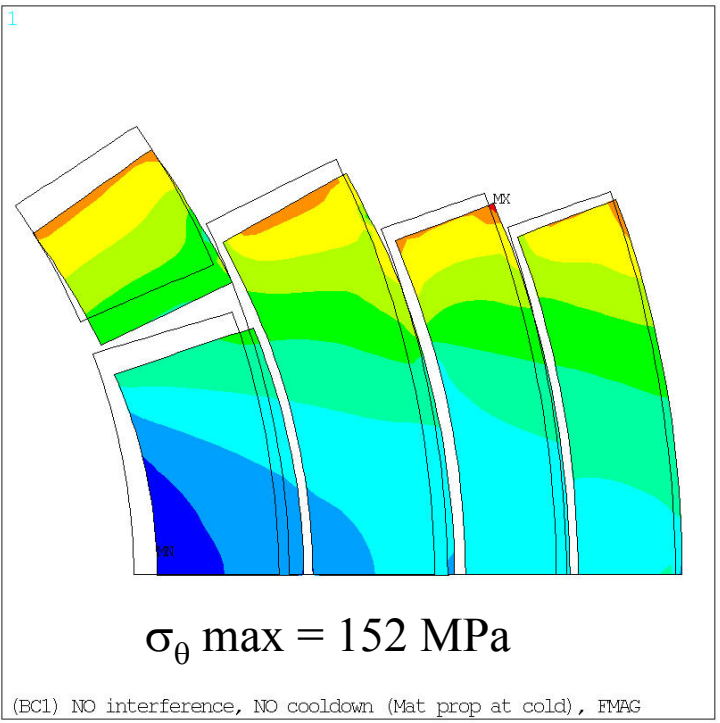
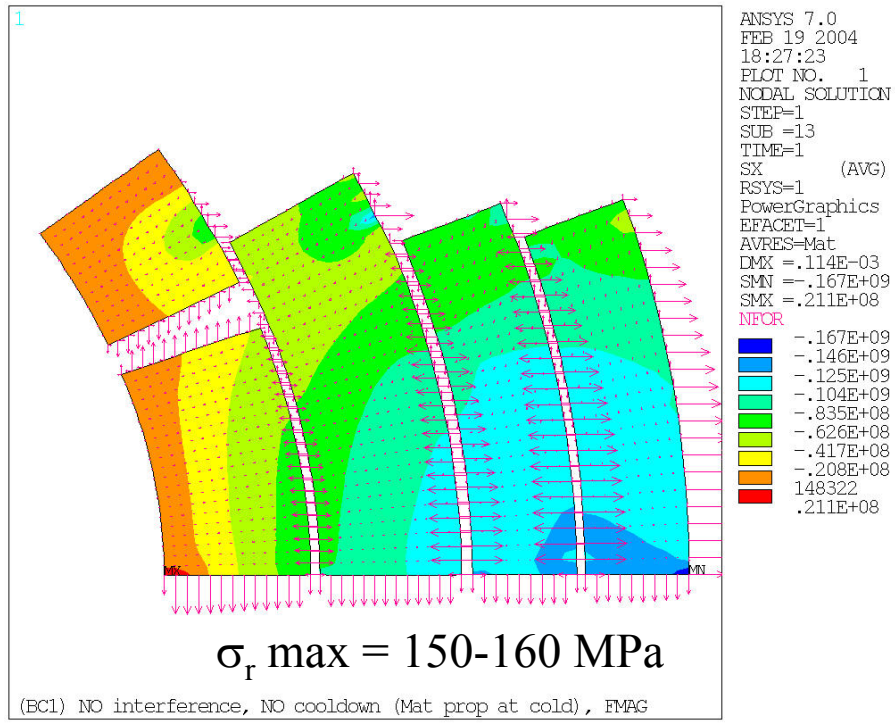
Shell type
Infinitely rigid B.C.

- **Stress in the coil with infinitely rigid BC on the outer surface of the collars**
  - **NO pre-stress**
  - **Material properties @ 4.2 K**
  - **Fmag @ 13 kA = 228 T/m**







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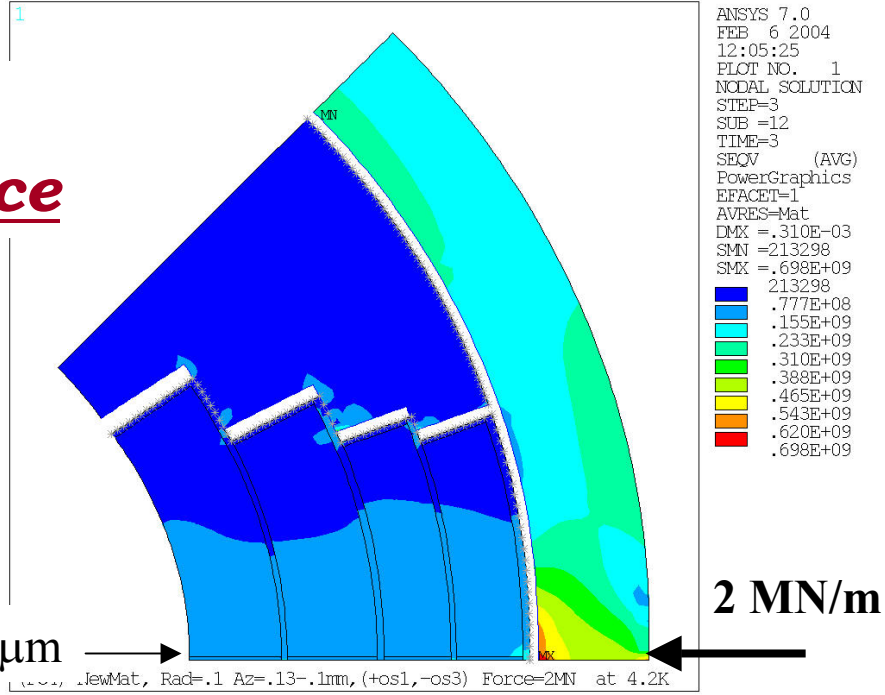
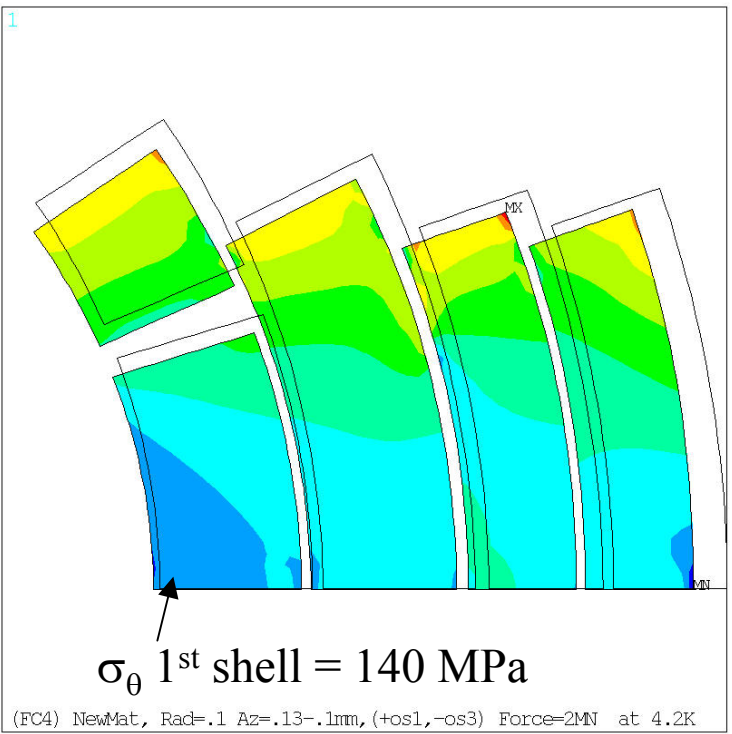
Shell type FEM with external force

- **Stress in the coil with horizontal force on the midplane**
  - **With some pre-stress <120 MPa**
  - **Fmag @ 13 kA = 228 T/m**

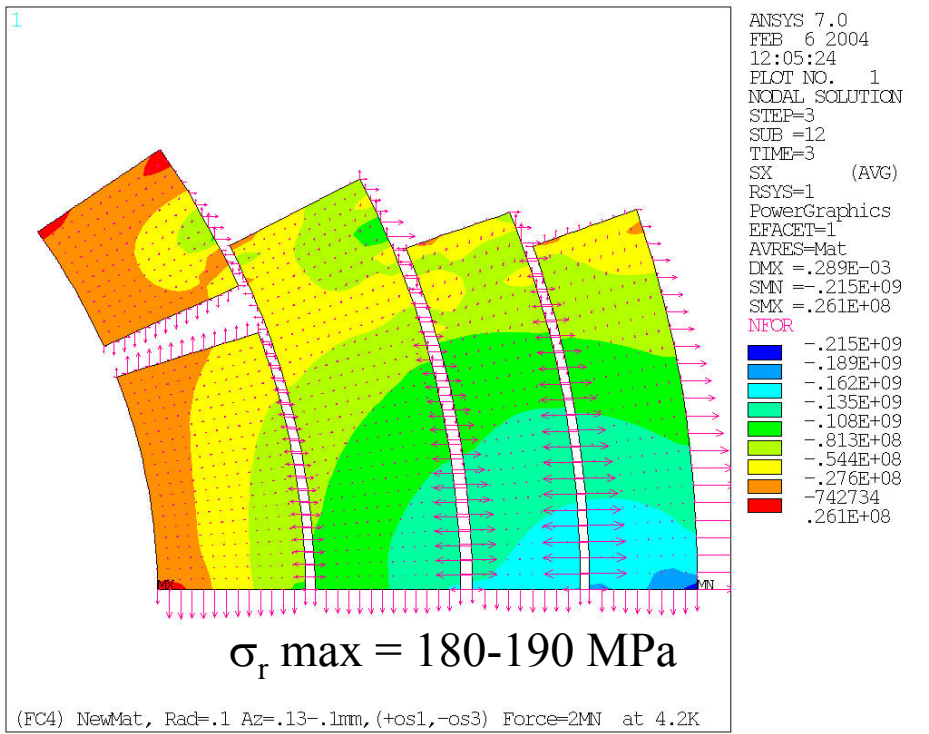


$\Delta r = 203\ \mu m$ ⟶

2 MN/m ⟵



σ_θ 1st shell = 140 MPa



σ_r max = 180-190 MPa

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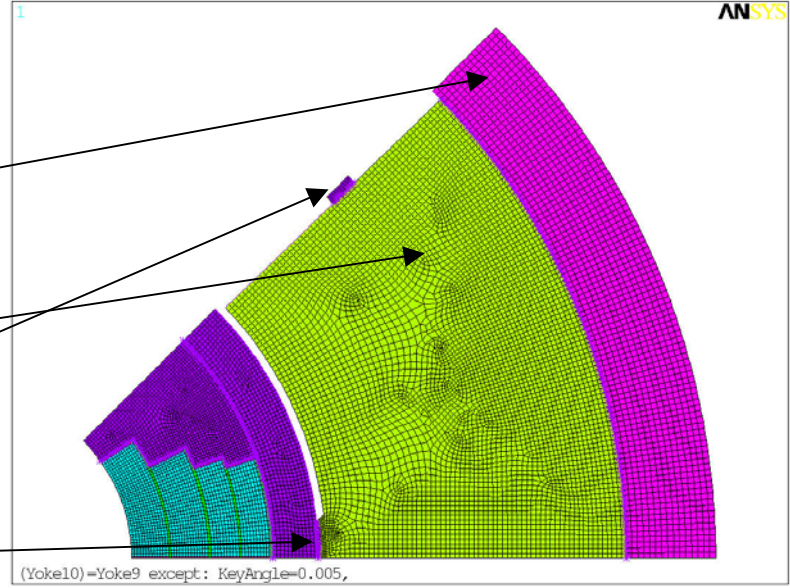
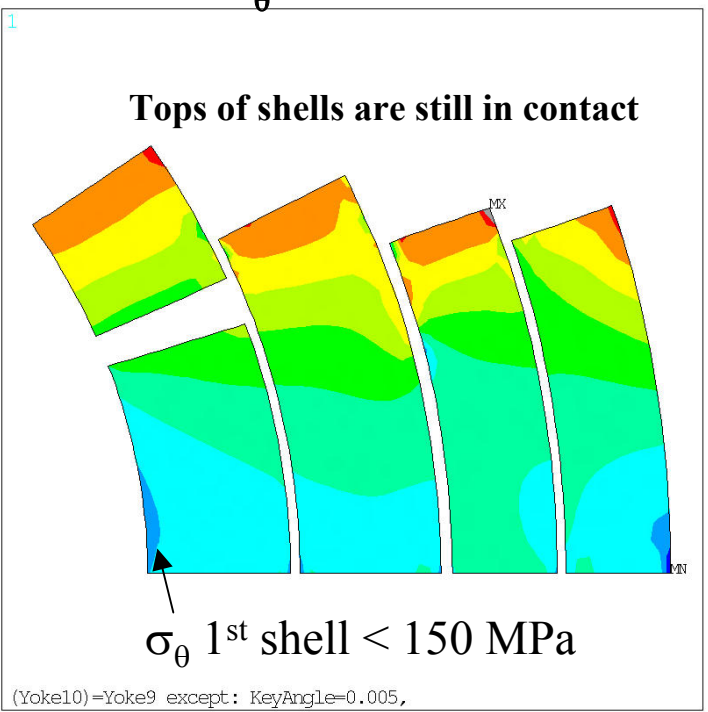
Shell type with Al outer shell

- Al shell
- Yoke with gap at 45 deg.
- SS keys in contact after cooldown and at max Grad.
- Collar-Yoke contact 0-6 deg.
- Bladder technology

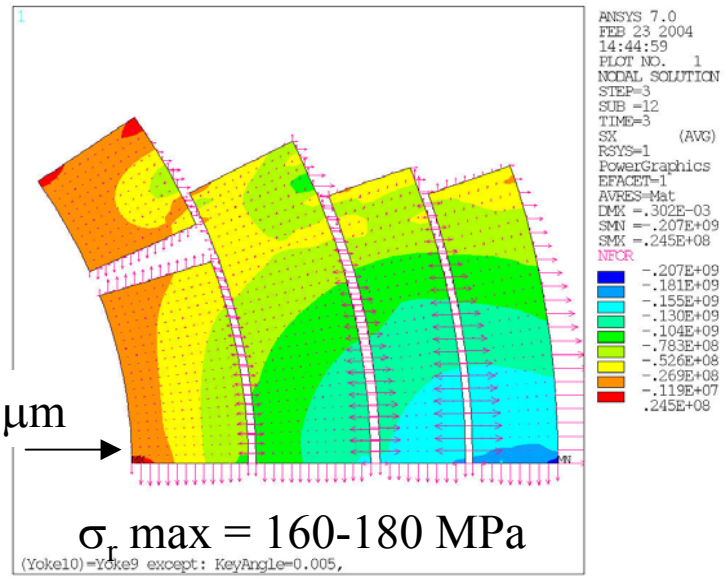


σ_θ at 228 T/m



σ_θ 1st shell < 150 MPa

σ_r at 228 T/m



$\Delta r = 131\ \mu m$

σ_r max = 160-180 MPa

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Next steps

- **Shell type with SS skin** — By the end of Q2
- **Block type (F_x=5.5 F_y=-6 MN/m @ 228 T/m)** — By the end of Q3
  - **Analytical study**
  - **FEM with fixed BC**
  - **FEM with external help (force and/or BC)**
  - **Full FE model (conceptual)**
  - **Comparison with LBNL design**
- **Sensitivity analysis** — By the end of FY04
  - **As part of the decision process**

Decision for 1st short model

- **Final design of 1st short model with magnetic and mechanical optimization** — By the end of FY05